S-6/PHSH/CC-13/23

TDP (Honours) 6th Semester Exam., 2023

PHYSICS

(Honours)

THIRTEENTH PAPER : CC – 13

Full Marks : 60 *Time* : 3 Hours

*Answer from **both** the Groups as directed.*

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP—A

1. Answer *any* **six** of the following questions : 2×6=12

(a) Define the term 'wave impedence'.

(b) What do you understand by anomalous dispersion?

(c) Calculate the skin depth for radio waves of wavelength 3 m (in free space) in copper, the electrical conductivity of which is 6×10^7 S/m.

(d) Why is the quantity $\varepsilon_0 \frac{\partial E}{\partial t}$ referred to as a displacement current?

(e) What is the nature of emergent polarised light when circularly polarised light is passed through a quarter wave plate?

(f) What are ordinary and extraordinary refractive indices?

(g) Explain clearly the term 'specific rotation'.

(h) Define the term 'numerical aperture'.

GROUP—B

There are *four* questions from Question No. 2 to Question No. 5. Answer either *(a)* **or** *(b)* from each question given below : 12×4=48

2. *(a)* *(i)* Starting from Maxwell's equations show that in a homogeneous isotropic dielectric medium of permittivity ε and permeability μ, the velocity of an electromagnetic wave is given by

$$v = \frac{1}{\sqrt{\mu\varepsilon}} .$$

(ii) Establish the boundary conditions that must be satisfied by the field vectors when an electromagnetic wave is incident at the interface between two dielectric media.

(iii) A plane electromagnetic wave travels in free space in negative z-direction with a propagation constant 20 rad/m, the amplitude of the magnetic field being $\frac{40}{377}$ A/m. At $t = 0$ and $z = 0$, the magnetic field has the direction $-a_y$. Give expressions for $\vec{E}$ and $\vec{H}$. Also find the frequency and the wavelength. 4+3+(3+1+1)=12

(OR)

(b) *(i)* Show that $\vec{B} = \frac{1}{c}\left(\hat{n} \times \vec{E}\right)$, where $\hat{n}$ is the unit vector in the direction of propagation and c is the speed of light in free space.

(ii) Explain the physical significance of Maxwell's equations of electromagnetism.

(iii) Derive the law of conservation of charge from Maxwell's field equations.

(iv) Show that under a gauge transformation of vector potential $\vec{A}$ and scalar potential ϕ, the electromagnetic field equations are invariant. 3+3+3+3=12

3. (a) (i) Deduce Fresnel's laws of reflection and refraction from the electromagnetic theory of light.

(ii) An electromagnetic wave is incident on the interface between two dielectric media. What are the boundary conditions that must be satisfied by the field vectors? Show that the frequency of the incident wave remains unchanged by reflection and transmission.

(iii) Explain the significance of Brewster's angle. Find the Brewster's angle for a glass-oil boundary for external and internal reflections. Given refractive index for glass 1·52 and that of oil 1·81.

3+(2+3)+(2+2)=12

(OR)

(b) (i) Give Lorentz's theory of dispersion and find the connection between absorption and anomalous dispersion.

(ii) Write the equation of motion of an electron in a radiation field. What is radiation damping?

(iii) Show that high frequency electromagnetic wave propagate only a small distance inside a conductor.

(iv) Why is the refractive index of glass for X-rays less than unity?

(2+3)+(1+2)+2+2=12

4. (a) (i) Discuss the phenomenon of double refraction and describe in detail what happens when a ray of light is allowed to pass successively through two glass plates of calcite, the second being rotated about the incident beam. Show that the intensity of the emergent beam is same as that of the incident beam.

(ii) Explain the working of quarter wave and half wave plate. Also calculate their thickness.

(iii) How will you distinguish between elliptically polarised light and a mixture of plane polarised and unpolarised light?

(3+2)+(2+2)+3=12

(OR)

(b) (i) Describe the construction, working and use of Nicol prism.

(ii) Explain how you would detect beams of circularly and elliptically polarised lights.

(iii) Linearly polarised light is changed into circularly polarised light after passing through a slice of crystal $2{\cdot}5 \times 10^{-5}$ m thick. If the difference in refractive index for ordinary and extraordinary ray is 0·005, find the wavelength of light used.

(2+3+1)+(2+2)+2=12

5. *(a)* *(i)* Give Fresnel's explanation of rotation of plane of polarisation by an optically active substance.

(ii) Describe the construction and principle of Laurent's half-shade polarimeter. How will you use it to find the strength of sugar solution?

(iii) State Biot's law of Rotatory polarization.

3+(2+3+2)+2=12

(OR)

(b) *(i)* Derive the expression for field components of *TE* waves in rectangular waveguide.

(ii) Why are circular waveguides not preferred over rectangular waveguides? What is meant by group velocity of the guided wave?

(iii) A step index fiber has normalized frequency 26·6 Hz at a 1300 nm wavelength. If the core radius is 25 μm. Find the numerical aperture.

(iv) What are the advantages of single mode fibre over multiple mode fibre?

4+(2+1)+3+2=12

★ ★ ★